Open Repair of Chronic Aortic Dissections Using Deep Hypothermia and Circulatory Arrest

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Background. **There has been great enthusiasm for thoracic endograft repair of chronic thoracic or thoracoabdominal aortic dissection (ChAD) given the low operative morbidity and mortality. However long-term results are unknown and early reintervention is common. This study examines the early and late results of open repair of ChAD using deep hypothermia and circulatory arrest (DHCA).**

Methods. **From January 1995 to December 2009, 343 patients had open repair of descending thoracic or thoracoabdominal aneurysms using DHCA. Of these individuals, 93 patients had open repair of ChAD with DHCA. All patients undergoing elective procedures underwent preoperative cardiac catheterization. Lumbar drains were not placed preoperatively. Visceral or renal artery bypass was performed in 20% of patients. Supraaortic branches were bypassed in 14% of patients.**

Results. **Mean age was 60 ± 14 years. Men composed 77% of the cohort. Aortic replacement encompassed the descending aorta in 29% of patients, type I thoracoabdominal repair was performed in 25% of patients, type II thoracoabdominal repair was performed in 40% of patients, and arch replacement was performed in 24% of patients. Operative mortality was 2.2%, renal failure requiring dialysis was 0%, paralysis occurred in 1.1% of patients, stroke occurred in 1.1% of patients, prolonged intubation was needed in 9.7% of patients, and tracheostomy was needed in 2.2% of patients. Postoperative length of stay was 10.5 ± 7.6 days. One-, 3-, 5-, and 10-year survival rates were 93%, 90%, 79%, and 61%, respectively. Reintervention was necessary in 2.2% of patients for graft infection, in 2.2% of patients for anastomotic pseudoaneurysm, and in 4.4% of patients for growth of a distal aortic aneurysm.**

Conclusions. **Open repair of ChAD with DHCA has low operative morbidity and mortality. Long-term survival is very good with low rates of reintervention. Endovascular repair of ChAD does not have proven short- or long-term efficacy.**

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Open repair for descending thoracic or thoracoabdominal chronic aortic dissection traditionally was associated with an operative mortality of 7.5% to 15% and a rate of neurologic deficit from 9% to 28% [1–4]. A variety of surgical techniques has been used as surgical experience and technology have progressed; however operative mortality has remained stable. Enthusiasm for thoracic endovascular aortic repair (TEVAR) for chronic aortic dissection has grown, as the procedural mortality has been quite low [5–13]. However reintervention rates for TEVAR in ChAD are significantly high. Additionally, the success of TEVAR for ChAD hinges on "thromboexclusion" of the false lumen, which varies from 40% to 80% at the level of the thoracic endograft and is considerably lower distal to the thoracic endograft [5–13].

We have previously reported low rates of morbidity and operative mortality and excellent long-term survival for replacement of the descending thoracic and thoracoabdominal aorta using our preferred technique of deep hypothermia and circulatory arrest (DHCA) [14,15]. In this study, we report a series of 93 patients with ChAD who had transverse arch, descending, or thoracoabdominal aortic replacement, or a combination, using DHCA.

Material and Methods

Institutional Review Board of Indiana University approval was obtained for this retrospective study. Individual patient consent was waived. From January 1995 to December 2009, 343 patients underwent descending thoracic or thoracoabdominal aneurysm repair using DHCA [15]. Of these patients, 93 had either a Stanford type A aortic dissection that had undergone previous proximal repair or a Stanford type B aortic dissection in the chronic phase of disease. The indications for arch, descending, or thoracoabdominal aneurysm repair were an overall aortic diameter of at least 5.0 to 5.5 cm; aneurysm growth rate of greater than 1.0 cm per year; chest, back, or abdominal pain that could not be explained by other diagnoses; uncontrolled hypertension despite the patient receiving multiple antihypertensive medications; chronic malperfusion of abdominal viscera or rupture.

All patients undergoing elective procedures underwent preoperative cardiac catheterization. Left-sided coronary artery disease was addressed at the time of de-

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scending thoracic aneurysm (DTA) or type I or II thoracoabdominal aneurysm (TAAA) repair with adjunctive coronary artery bypass. Right-sided lesions or significant coronary artery disease with type III or IV TAAA repair were addressed with preoperative percutaneous coronary intervention or a first-stage surgical procedure entailing coronary artery bypass and repair of proximal aneurysm followed by a second-stage repair. There were 5 (5.4%) patients in the series who had emergent or urgent operations, only 1 of whom underwent preoperative cardiac catheterization; this procedure is pursued unless the clinical situation (ie, rupture or impending rupture) does not permit it.

Operative Technique

Details of the surgical technique have been discussed elsewhere [14, 15]. Methylprednisolone 500 mg and aminocaproic acid 10 mg are administered at the beginning of the operation before cardiopulmonary bypass. Aminocaproic acid (5 mg) is administered again in the cardiopulmonary bypass circuit after 3 hours.

The patient is placed on cardiopulmonary bypass through the left common femoral artery (Fem-Flex II Femoral Arterial Cannula, Edwards Lifesciences, LLC, Irvine, CA) and vein (Carpentier Bi-Caval Femoral Venous Cannula, Medtronic, Inc, Minneapolis, MN). Arterial pulsatility is maintained for 5 minutes before engaging full cardiopulmonary bypass. The patient is cooled to an arterial circuit temperature of 15°C. Cooling continues until the temperature of the venous return blood is 20°C for at least 30 minutes, which typically amounts to 40 to 50 minutes of cooling time. When the heart fibrillates, a left ventricular sump vent (Argyle Left Ventricular Sump Vent Catheter, Covidien, Mansfield, MA) is placed through the left ventricular apex. All patients have saturation monitors placed on the forehead and the bilateral lower extremities (INVOS Cerebral/Somatic Oximeter, Somanetics Corp, Troy, MI) to monitor cerebral saturations as well as lower extremity saturations.

Before circulatory arrest, the patient is placed in steep Trendelenberg position and rolled to the right, placing the ascending aorta in the most dependent position. Potassium chloride (30 to 60 mEq) is placed into the cardiopulmonary bypass circuit to achieve cardiac diastolic arrest. Once the heart has arrested, the left ventricular sump vent is turned off, the venous line is clamped, and the arterial flow is halted. A cross-clamp is placed across the mid descending thoracic aorta, and low arterial flow (1 L/min) is restarted from the femoral arterial cannula. The proximal descending aorta and arch are opened, and the proximal anastomosis is performed, keeping the arch full of blood to prevent air penetration into the ascending aorta and arch vessels. Arterial flow is reinstituted through a second arterial circuit through the perfusion sidearm of the thoracoabdominal graft (Vascutek Gelweave, Terumo Cardiovascular Systems Corp, Ann Arbor, MI). The complex cardiopulmonary bypass circuit allows differential flow through the multiple arterial lines. Therefore arterial flow to the upper body and lower body can be adjusted individually as needed.

The femoral artery flow is halted and the remainder of the thoracoabdominal aorta is opened. The order of the anastomoses progresses distally. Intercostal island bypasses are performed using a looped 10-mm graft (Vascutek Gelsoft, Terumo Cardiovascular Systems Corp) [16]. If the visceral abdominal aortic segment is involved, perfusion catheters are placed (9F Pruitt Irrigation Occlusion Catheter, LeMaitre Vascular, Inc, Burlington, MA) into the ostia of the celiac, superior mesenteric, right renal, and left renal arteries to achieve a flow of 250 to 350 mL/min into the visceral segment. The visceral perfusion is administered through a separate (third) arterial circuit. Either an island anastomosis or individual anastomoses are performed to the visceral arteries, depending on the complexity of the dissection or stenosis of the vessel. Finally, the distal anastomosis is performed.

The patient is warmed to 20°C once the perfusion to the intercostal arteries has resumed. The patient is warmed to 37°C before the final anastomosis. Once the arterial circuit temperature has reached 30°C, the heart is defibrillated. Once the arterial system has been fully reconstructed, perfusion is restored to the entire body though a single arterial circuit until separation from cardiopulmonary bypass.

Neurologic Monitoring

Intraoperative somatosensory evoked potential (SSEP) and motor-evoked potential (MEP) monitoring was performed for all TAAA repairs. Anesthetic technique was composed of total intravenous anesthesia using propofol and remifentanil. Baseline readings for SSEP and MEP were obtained before the start of the procedure. Readings were not taken again until the patient had been separated from cardiopulmonary bypass. The presence of SSEP and MEP after transcranial stimulation indicated an intact spinal cord. Typically the potentials were lower in amplitude versus baseline because of scalp edema and the post hypothermic cardiopulmonary bypass state. Lumbar drains were placed postoperatively only when SSEP and MEP were absent in the lower extremities but present in the upper extremities. Mean arterial pressure was maintained between 80 and 100 mm Hg without evidence of spinal cord ischemia. Mean arterial pressure was elevated to 90 to 110 mm Hg with evidence of spinal cord ischemia.

Statistics

Survival data were obtained by querying the Social Security Death Index and the electronic medical record. Survival rates were computed using the method of Kaplan and Meier.

Results

Preoperative patient characteristics are listed in Table 1. The mean age was 60 ± 14 years. Men composed 77% of the cohort. Chronic type A and type B dissections were present in 49.5% and 50.5% of the patients, respectively. Previous thoracic aortic operations (replacement of the ascending aorta, arch, or proximal descending aorta)